RADE Public Field day

Lincoln University

10 December 2024

Whenua Haumanu

“Nurturing the land through exploring pastoral farming”

Lincoln University’s Dryland Pastures Research Group (www.drypandpastures.com) is conducting this experiment as the dryland component of the Massey University-led Whenua Haumanu programme (https://www.massey.ac.nz/about/colleges-schools-and-institutes/college-of-sciences/our-research/themes-and-research-strengths/whenua-haumanu/). Funded by the Ministry for Primary Industries (MPI). Whenua Haumanu is a partnership between Massey University and the MPI through the Sustainable Food and Fibre Futures fund. Programme delivery partners include Lincoln University, AgResearch, Manaaka Whenua and the Riddet Institute.

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Hazard summary – Field Research Centre managed research areas

By entering this experimental area, you are acknowledging your receipt of this hazard summary and your agreement to take personal responsibility to watch out for potential hazards and act in such a manner as to protect yourself and any others also on-site.

People

- Uninformed/ill-prepared/unauthorized visitors may be the greatest risk.
- Wear appropriate footwear and clothing for the conditions – including sunhats/sunscreen to prevent sunburn.
- Stay hydrated.
- Lincoln University has a strict no smoking/no vaping policy on campus.

Animals

- It is their space.
- They are not tame.
- Do not enter areas with stock present.
- Take no action which is likely to modify animal behaviour.
- No dogs are permitted on site.
- Leave all gates as you find them.

Potential slips/trips

- Uneven surfaces occur across the area.
- Rabbit burrows are present.
- Fences.
- Monitoring equipment within the paddocks (e.g. neutron probe access tubes).
- Toughs & salt lick blocks.

Research activities

- Avoid staff/students in the process of taking plant and animal measurements.
- Drones collect data here – the camera is operating. Do not enter the area within the operational windows without prior authorization.

Ears/Eyes

- Windblown seed/pollen/dust.
- Loud equipment/machinery.

Touch

- Treat electric fences as high voltage power sources.

Machinery, Tools & Vehicles

- Keep out of the road of all vehicles and farm equipment. Assume they can't see you.
- Tools and machinery generate noise/fragments. Maintain your distance.
- Authorised personnel only in the compound.
- Only authorised persons can operate machinery/vehicles/research equipment. Helmets must be worm if traveling in the mule.

Research activities and measurements take priority over all other on-site activities/access.
ARE YOU TRAINED FOR WHAT YOU ARE ABOUT TO DO? If not, STOP.
If you are uncertain how you should act or proceed, stop and contact the farm manager, other farm staff or your host.

Programme

Stop 1:
General introduction to the Regenerative Agriculture Dryland Experiment including housekeeping for the field day.

Stop 2:
Measurements being taken in Regenerative pastures (yield, composition, species in mixes).

Stop 3:
Fertiliser inputs and soil fertility levels – microbiology, carbon, nitrogen.

Stop 4:
Lucerne grazing management.
Soil moisture, light interception.

Stop 5:
Cocksfoot/subterranean clover and pasture conservation.

Stop 6:
Grazing management, animal production, animal health.
Wrap up and questions.

Refer to Figure 1 for location of stops.

Welcome to the Regenerative Agriculture Dryland Experiment

- The RADE is an 8-ha farmlet that aims to investigate the total-farm impacts of regenerative agriculture (RA) practices versus conventional best practices for dryland sheep production.
- The two systems are replicated across soils of two phosphorus (P) fertility levels to determine their ability to operate with less P fertiliser.

Design

- Treatments are a 2 × 2 factorial of regenerative (R) and conventional (C) practices and high (H) and low (L) soil P fertility (Olsen P 20 and 10).
- **Regenerative practice:** a system of diverse pastures and winter crops, rotational grazing with sheep at high stock densities and frequent shifts (2–3 days) and no herbicide.
- **Conventional practice:** a system of lucerne and cocksfoot/sub clover pastures and autumn-sown rape or annual ryegrass for the winter crop, rotational grazing with sheep at lower stock densities and less frequent shifts, and herbicide where required.
- The layout of treatments is a 4 × 4 Latin square design with five squares, to allow for effects of existing paddock, soil depth and hedges (Figure 1).
- Plot size is average 0.1 ha and range 0.087–0.132 ha.
- Twenty plots of the same treatment make up four autonomous farms of 1.936 ha.

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Figure 1 Latin square design with five 4 × 4 Latin squares of regenerative (R) and conventional (C) × high (H) and low (L) soil fertility treatments. Square 1 is Plots 1–17, Square 2 is 18–32, Square 3 is 33–48, Square 4 is 49–64 and Square 5 is 65–80. Red stars indicate today's field stops.

Forage types

- **Regenerative**:
  - Diverse with lucerne: 5 kg/ha 'Jeronimo' prairie grass, 1 kg/ha 'Choice' chicory , 0.5 kg/ha 'Safin' cocksfoot, 4 kg/ha 'Hummer' tall fescue, 4 kg/ha 'Oakdon' meadow fescue, 6 kg/ha of either 'Kaituna' (Square 1) or 'Takahē' (Square 2) lucerne, 0.3 kg/ha 'Maté' phalaris, 2 kg/ha 'WGB23587' timothy, 0.5 kg/ha 'Captain' plantain, 1 kg/ha 'Amigain' red clover, 0.3 kg/ha 'Legacy' white clover and 1 kg/ha 'Woogenellup' subterranean (sub) clover **(12 species)**.
  - Diverse without lucerne: same as above with lucerne replaced by 1 kg/ha 'Taipan' balansa clover **(12 species)**.
  - Annual crop: 0.8 kg/ha 'Titan' rape, 0.5 kg/ha 'York Globe' turnip, 1 kg/ha 'Pasja' leafy turnip, 5 kg/ha 'Devour' annual ryegrass, 1 kg/ha phacelia, 1 kg/ha 'Captain' plantain, 1.3 kg/ha 'Taipan' balansa clover and 1.3 kg/ha 'Lightning' Persian clover **(eight species)**.
- **Conventional**:
  - Lucerne: 15 kg/ha of either 'Kaituna' (Square 1) or 'Takahē' (Square 2) lucerne.
  - Cocksfoot/sub clover: 4 kg/ha 'Greenly II' cocksfoot, 10 kg/ha 'Denmark' and 10 kg/ha 'Narrikup' subterranean clover.
  - Annual crop: 4 kg/ha 'Titan' rape in Year 1 and 25 kg/ha 'Devour' annual ryegrass in each subsequent year.
- 'Diverse with lucerne' and lucerne pastures are compared in Squares 1, 2 and 4 (12 plots/farm), 'diverse without lucerne' versus cocksfoot/sub clover in Squares 3 and 5 (eight plots/farm) and diverse versus rape or annual ryegrass winter crops in two rows per annum in a pasture-crop-pasture rotation (two plots/farm).
- Established over 16 months as land became available: Squares 1 and 2 in December 2021, Square 3 in March 2022, Square 4 in October 2022 and Square 5 in March 2023.

Sheep

- Coopworth ewes and ewe lambs grazed the pastures during the establishment phase, from February 2022 to August 2023.
- 80 mature, in-lamb Bohepe ewes were allocated to farms on 1–17 August 2023.
- Mean lambing date was 28 August 2023 and weaning was on 6 December 2023.
- Ewes were shorn on 23 December 2023.
- 20 shorn Bohepe two-tooth ewes allocated to farms on 24 January 2024.
- From weaning, lambs were sold to a local meat factory when they reached a target minimum live weight of 35 kg from 11 December 2023 to 12 February 2024.
- Remaining trade lambs that did not reach 35 kg exited the farms on 7 February 2024.

- 24 ewe lambs and six ram lambs were retained for breeding and shorn 5 March 2024.
- 100 Bohepe ewes were mated with the Bohepe rams on 29 March–15 April 2024 (17 days) and then South Suffolk rams on 15 April–10 May 2024 (25 days).
- Mean lambing date was 1 September 2024 and weaning was on 3 December 2024.
- Stocking rate is adjusted annually – currently 12 ewes/ha on each farm (20 mature ewes and four hoggets/farm) (Figure 10).
- Conventional flocks are divided into two mobs/farm to create the low stock density and shift-frequency treatment.

Fertiliser inputs

Table 1 Mean fertiliser input for regenerative (R) and conventional (C) x high (H) and low (L) soil fertility farms.

Year	Farm	P (kg/ha)	S (kg/ha)	N (kg/ha)	Lime (kg/ha)
2021-22	HR	33	54	0	1,438
	HC	30	51	3*	1,438
	LR	1	4	0	1,438
	LC	5	8	3*	1,438
2022-23	HR	10	12	0	0
	HC	11	13	0	0
	LR	2	5	0	0
	LC	2	5	0	0
2023-24	HR	41	150	0	0
	HC	41	150	0	0
	LR	1	101	0	0
	LC	2	101	0	0
2024-25	HR	19**	18	0	0
	HC	18	40	0	0
	LR	0	18	0	0
	LC	0	18	0	0

*N fertiliser applied to one crop of winter rape/farm.
**P fertiliser was RPR for Regenerative and Superphosphate for Conventional in 2024-25.

Table 2 Mean soil pH, Olsen P and sulphate S in the top 0–75 mm of the soil for regenerative (R) and conventional (C) x high (H) and low (L) soil fertility farms.

Date	Farm	pH	Olsen P (mg/kg)	Sulphate S (mg/kg)
25/08/2023	HR	6.3	15	5
	HC	6.4	15	5
	LR	6.4	13	3
	LC	6.3	13	3
11/07/2024	HR	-	22	-
	HC	-	21	-
	LR	-	14	-
	LC	-	14	-

Yield and botanical composition

Herbage mass and its botanical composition is measured before and after each plot is grazed, topped, or cut for hay, for each harvested plot, and once a month for all 80 plots.

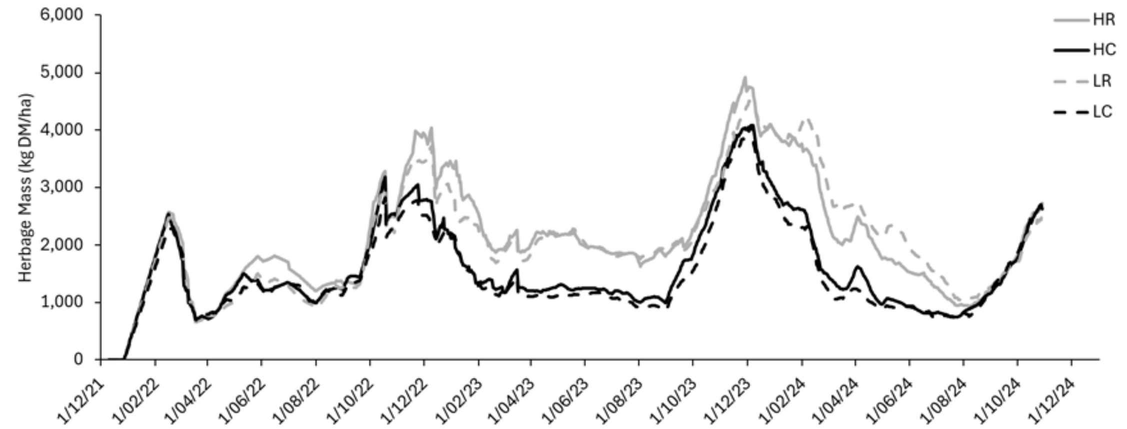

Figure 2 Herbage dry matter (DM) mass of regenerative (R) and conventional (C) x high (H) and low (L) soil fertility farms.

Herbage yield is calculated as the change in herbage mass between defoliations and summed over each year for all 80 plots. Current yield data are available up to 30 June 2024.

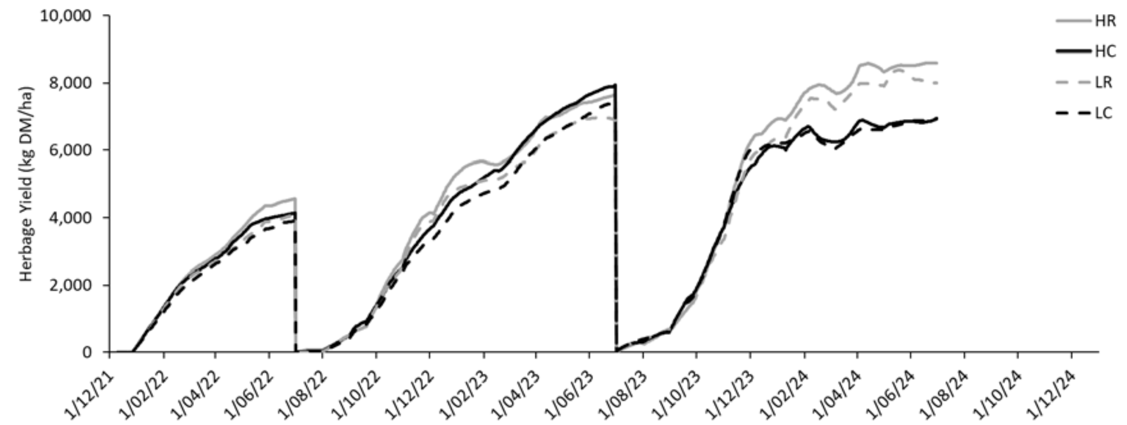

Figure 3 Herbage dry matter (DM) yield of regenerative (R) and conventional (C) x high (H) and low (L) soil fertility farms.

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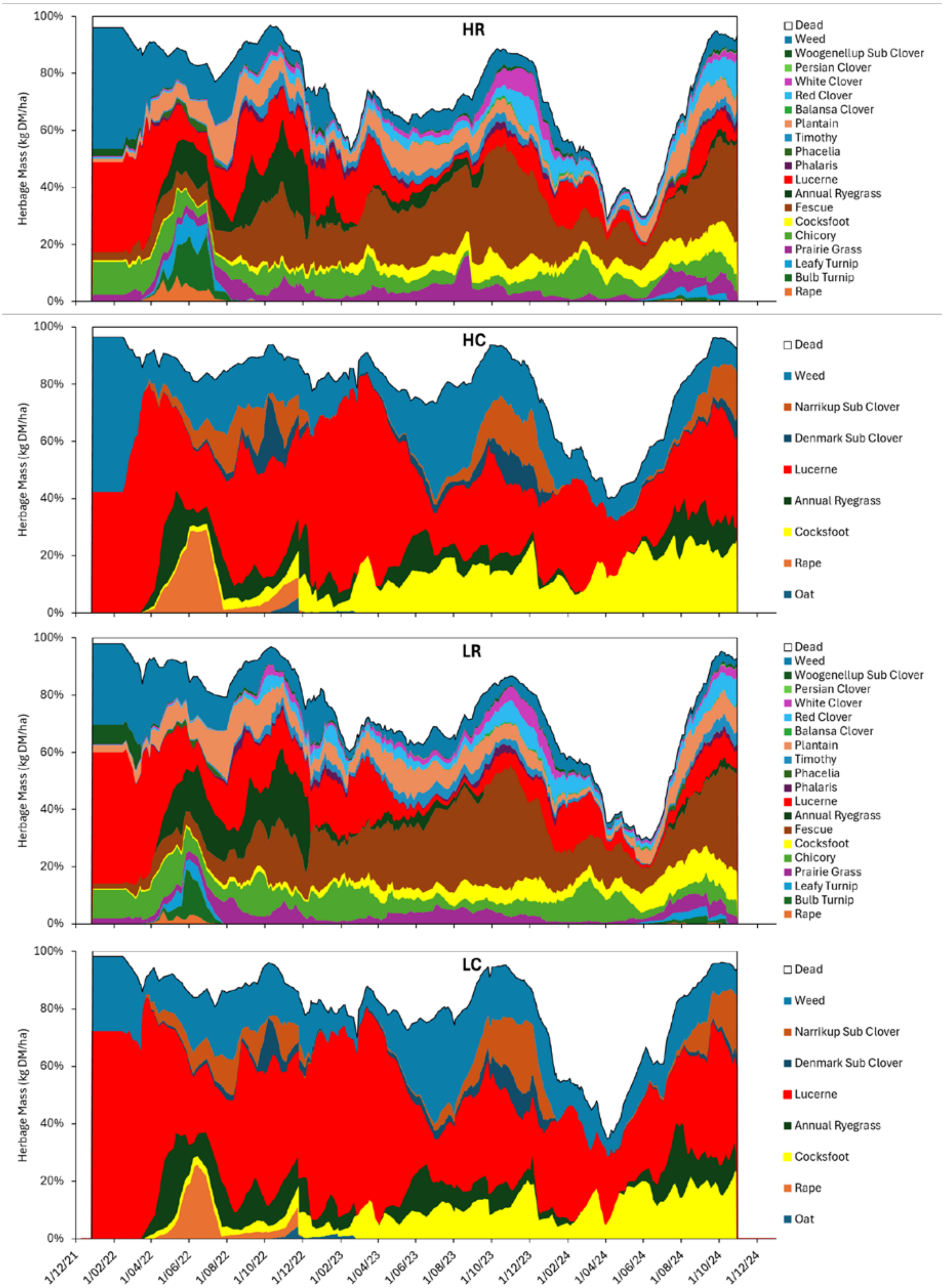

Figure 4 Botanical composition of herbage dry matter (DM) mass for regenerative (R) and conventional (C) x high (H) and low (L) soil fertility farms.

Soil fertility

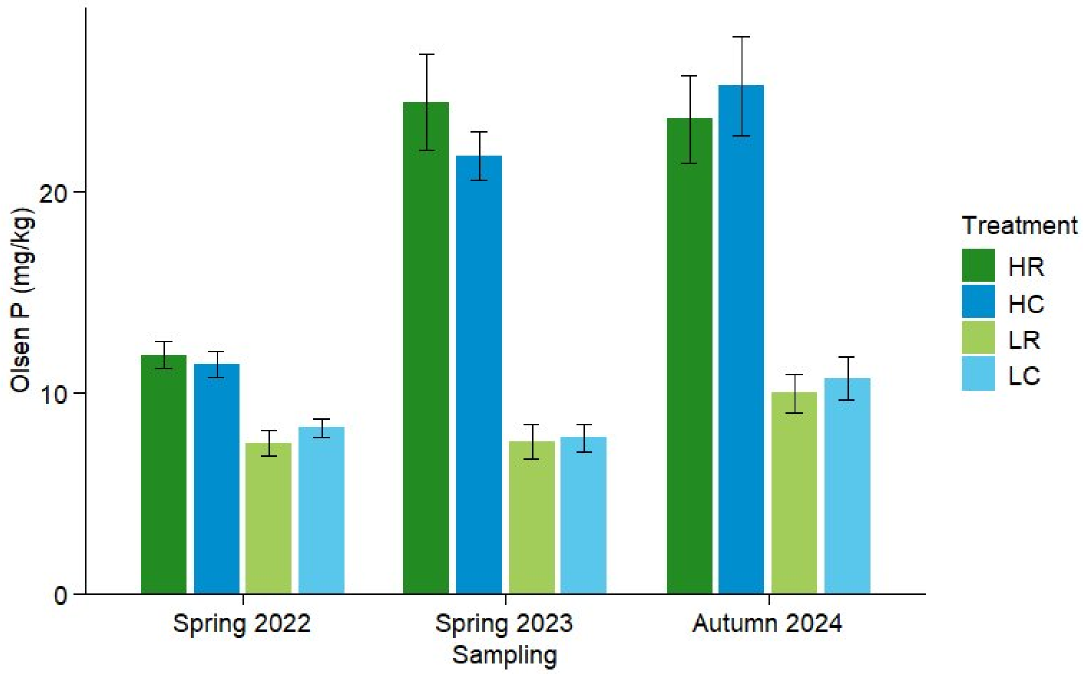

Figure 5 Olsen P (mg/kg) of high (H) and low (L) fertility Regenerative (R) and Conventional (C) pastures measured in spring over three growth seasons at the RADE experiment at Lincoln University, Canterbury.

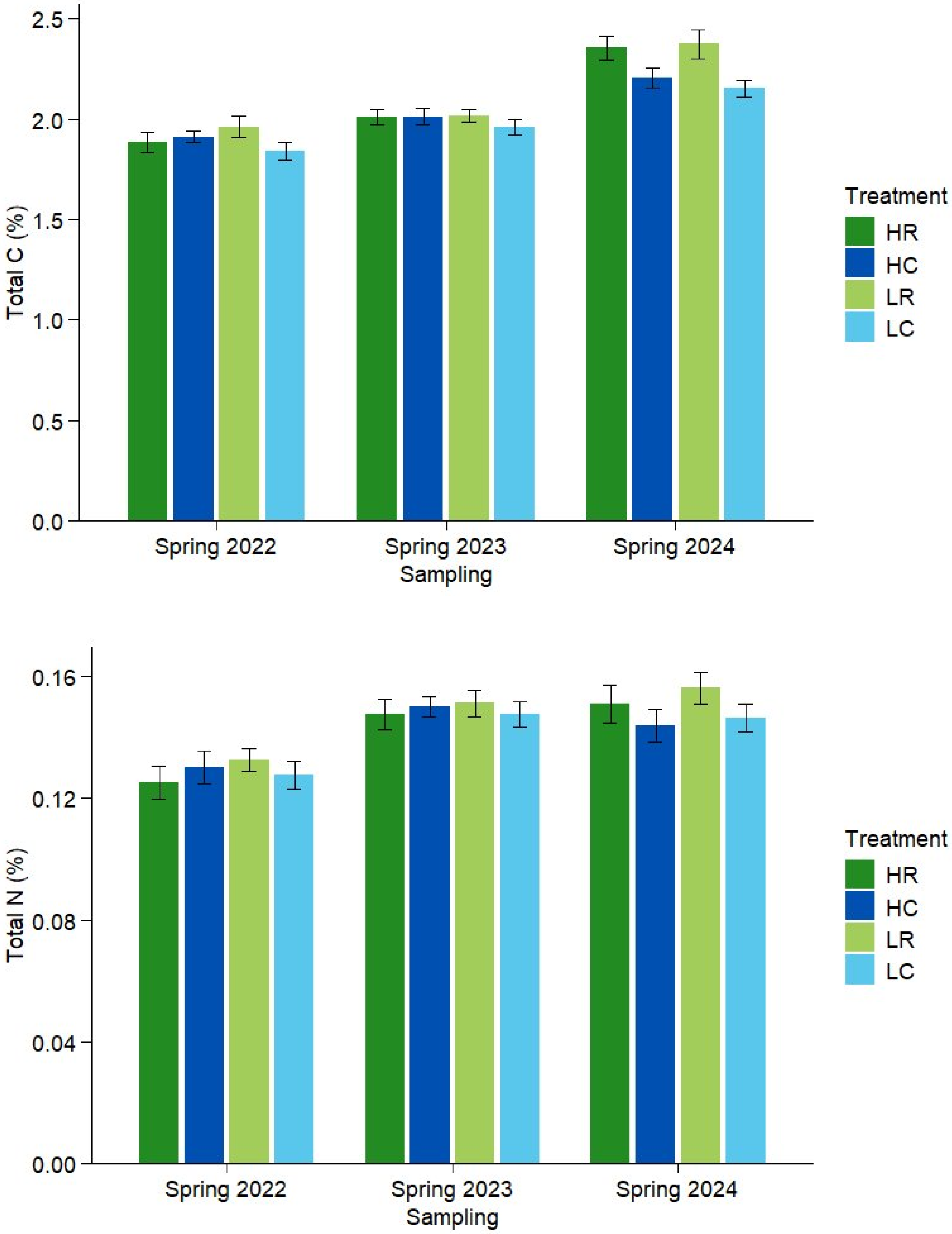

Figure 6 (top) Total soil carbon (C; %) and (bottom) total soil nitrogen (N; %) of high (H) and low (L) fertility Regenerative (R) and Conventional (C) pastures measured in spring over three growth seasons at the RADE experiment at Lincoln University, Canterbury.

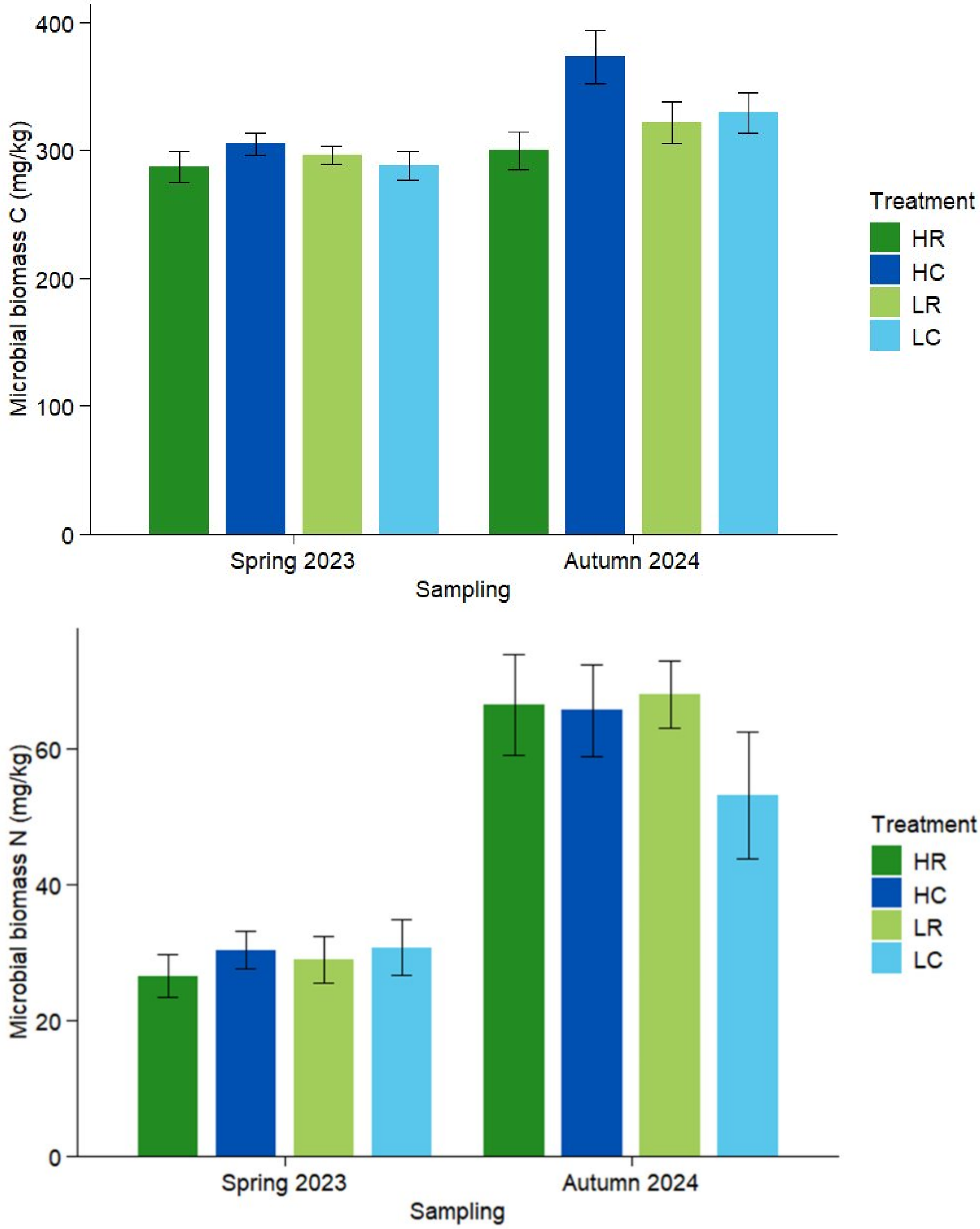

Figure 7 (top) Microbial biomass carbon (C; mg/kg) and (bottom) nitrogen (N; mg/kg) of high (H) and low (L) fertility Regenerative (R) and Conventional (C) pastures measured at two sampling dates at the RADE experiment at Lincoln University, Canterbury.

Lucerne: Agronomy

Prepared by Prof. Derrick Moot Lincoln University.
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Establishment

- pH>6.0 – soil test
- 5-7 kg/ha of inoculated bare seed equivalent
- Allow 50% flowering in spring establishment crop
- Free draining soil
- Modern cultivars are pest resistant

Weed control

- Graze at 20 cm if weedy – then allow flowering
- Early- mid winter control of annual and perennial weeds
- Paraquat burns leaves so early control essential

Fertiliser

- Hungry for nutrients if always conserved
  e.g. 20 kg K/ha/t DM removed
- Use potassic based fertilizer
- Nitrogen not required

Animal health

- Na is stored in roots so may be deficient for animals, use salt.
- Bloat on high quality feed - fibre available especially for lush feed
- Red gut – rapid passage of high quality feed – watch early spring
- Offer e.g. meadow hay to reduce possibility of red gut or mow
- Flushing in dry years – avoid lucerne with leaf spots
- If in doubt – 2 weeks off lucerne before ram goes out

Conservation

- Leaf is the high-quality component
- Bale with dew
- Silage should be wilted and may need an inoculant
- Spring crop is heaviest and vegetative (but why bale it?)

Irrigation

- Minimal at establishment (encourage root growth)
- 10-14 days after grazing (no leaf = no demand) big drinks 40-60 mm
- Encourages weed seed germination – so wait for leaf
- Sitting water rots root

Lucerne: Grazing management for production and persistence

Prepared by Prof. Derrick Moot Lincoln University.
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Autumn recovery (Feb/Mar)

- Allow >50% of stems with an open flower to encourage root recharge
- Graze if terminal drought but then allow recovery after rainfall until growth stops.

Winter weeds (June/July)

- Hard graze with large mob once frosts stops growth
- Apply weed control 14 days later
- Node accumulation on stems sets up spring potential
- Late spray or early ‘green pick’ drastically delays spring growth and reduces yield

Spring production (Sept/Oct/Nov)

- Begin grazing with ewes and lambs at crop height ~10 cm (1000 kg/ha)
- 3-10 day break e.g. 14 ewes + lambs/ha (over 20 ha = 280 mob)
- 5-6 paddock rotation (30-40 days recovery) – aim for 30 cm on re-entry
- Salt the chips – lucerne is low in foliar sodium so offer salt licks!
- Post weaning - Lambs only eat lucerne leaf– 70/ha? Ewes follow
- 2.5-4.0 kg DM/hd allowance
- Minimum of 6-8 weeks on lucerne to maximize LWG
- High quality leaf (ME >12, protein >24%)
- Low quality stem (ME~8, protein <14%)
- Graze before flowering
- Delayed harvest increases proportion of stem

Summer holiday (Dec/Jan)

- Go fishing
- Early flowering – low thermal time target and warm temperatures
- Shorter rotation 30-35 day return -low yields
- Water stress accelerates flowering but leaf is still high quality
- Conserve a true surplus

Soil water measurement

- Measured by TDR (0-0.2 m in plots 1-16 and 0-0.5 m in plots 17-80) and neutron probe at 0.1 m intervals (to 2.3 m depth (plots 1-16).
- This means that there are 23 readings plot in plots 1-16.
- Each 0.1 m layer stores soil water – like a series of buckets.
- Regular monitoring allows us to observe when the pastures start extracting water from different layers in the profile over time.

- In Canterbury potential evapotranspiration (PET) exceeds rainfall from September to April in most years.
- Potential evapotranspiration is a measure of atmospherically driven water demand by an actively growing crop/pasture with full canopy cover.
- In a dryland (rainfed) system when water supply from rainfall falls below atmospherically driven demand soil deficits develop. This is the period when roots extract soil moisture stored in the soil to allow growth to continue.
- Figure 8 shows how the soil profile (0-2.3 m) dries as water is extracted from Summer 2021. A reading of zero means the soil is at field capacity (all soil layers are full).
- Note that winter rainfall in 2024 was not enough to recharge the soil to field capacity – effectively we started the 2024/25 growth season with a smaller bucket of water for pasture growth.

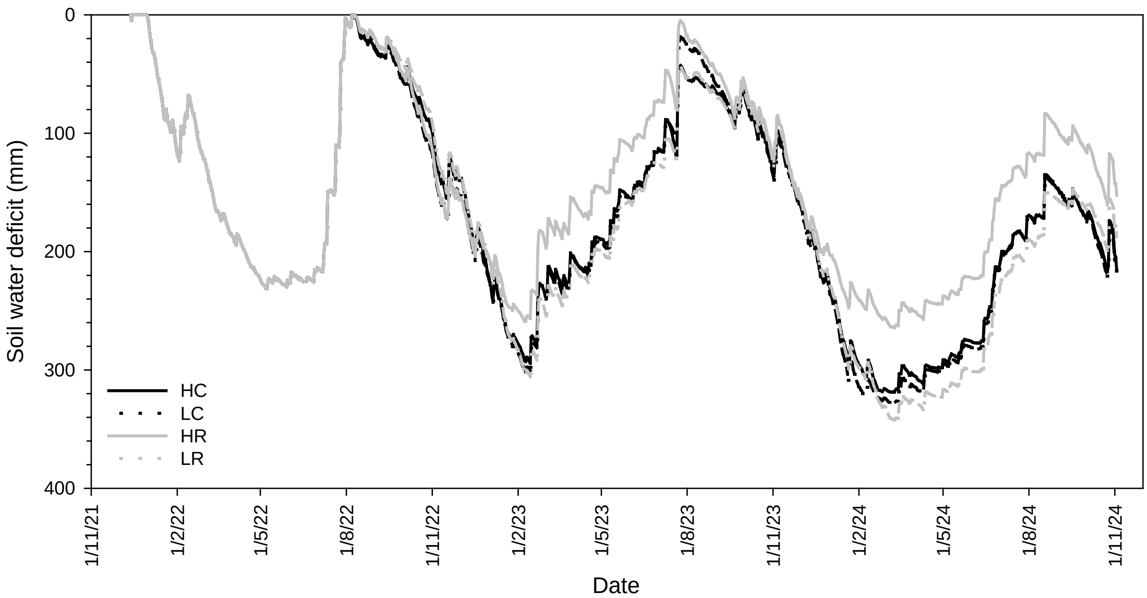

Figure 8 Soil water deficit of four pasture treatments at the RADE experiment at Lincoln University from summer 2021. Treatment means are calculated across all 80 plots.

Figure 9 shows the change in soil moisture in Plot 6 (a high fertility regenerative pasture mix) and Plot 5 (a high fertility conventional pasture) at three dates this spring relative to the upper (DUL) and lower (LL) water holding capacity in each soil layer. Plot 1 is an establishing low fertility conventional pasture mix showing the benefit of the fallow period.

- The grey area (below the dotted LL line) is not available for growth – physically the plants cannot extract this water.
- The solid black line (DUL) is how much water can be held in each soil layer when at field capacity (“full”).
- The difference between DUL and LL is the amount of water the plants can access for growth in addition to rain that falls within the growth season.
- On 27 November the established pastures had 60-75 mm of plant available water remained in the profile. If PET averages 5 mm/d, and we assume growth continues at the maximum rate, we will run out of water in about 12-15 days in these two plots.
- For Plot 1, the establishing conventional pasture, pastures would continue to grow for almost another month if using 5 mm/d as plant root growth continues to explore and extract water, even though the lower soil layers didn’t completely recharge over winter.
- In practice, soil water becomes harder to extract as the soil dries, less water than potential is extracted and growth slows, then ceases.

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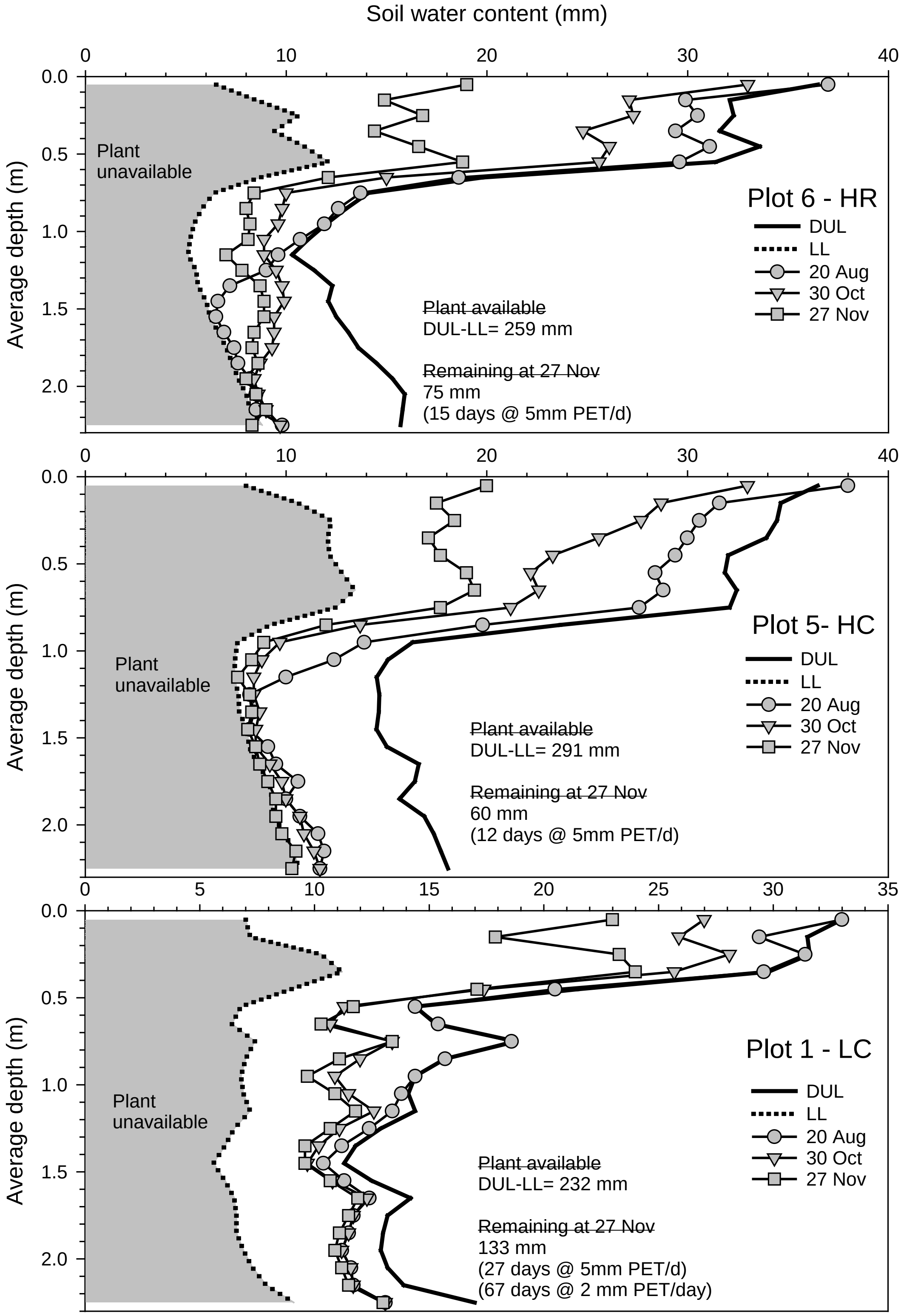

Figure 9 Change in soil water content (mm) in 23 soil layers (0-2.3 m) in established pastures in Plot 9 (HR = High fertility Regenerative pasture) and Plot 12 (HC = High fertility Conventional pasture). Plot 4 is an establishing HR pasture.

Sub clover management

Table 3 Subterranean clover grazing management regime (Olykan *et al*. 2019).

Month	Grazing management
Jan–Feb	Beef cows intensively graze last of mature reproductive grass down to 600 kg DM/ha pasture cover. May use electric wires to pressure stock to avoid patch grazing.
Feb–Mar	Look for sub clover germinating after early autumn rain and spell until seedlings have 3–4 trifoliate leaves.
Apr–Jun	When required, use a mob of 100 hoggets/ha to control grass cover down to 50 mm for 1 to 2 days
Jul–Aug	Set stocked ewes with twins at 6/ha from late July with 1.5 heifers/ha
Sep	From late September, as sub clover starts to flower, take ewes and lambs off to legume-dominant lowland paddocks. Leave 1.5 heifers/cows/ha in the block during Oct.
Oct	If sufficient sub clover exists after weaning lambs on 1 Oct, put in 250 weaned lambs (~20/ha) to graze down to 1200 kg DM/ha.
Nov–Dec	No stock until end of December to allow sub runners to spread and set seed.
Late Dec	Depending on feed quality, run hoggets or ewes through first. Then graze cattle, e.g. trade heifers, to clean-up the mature grass and graze as seasonal rainfall allows.

Stocking rate

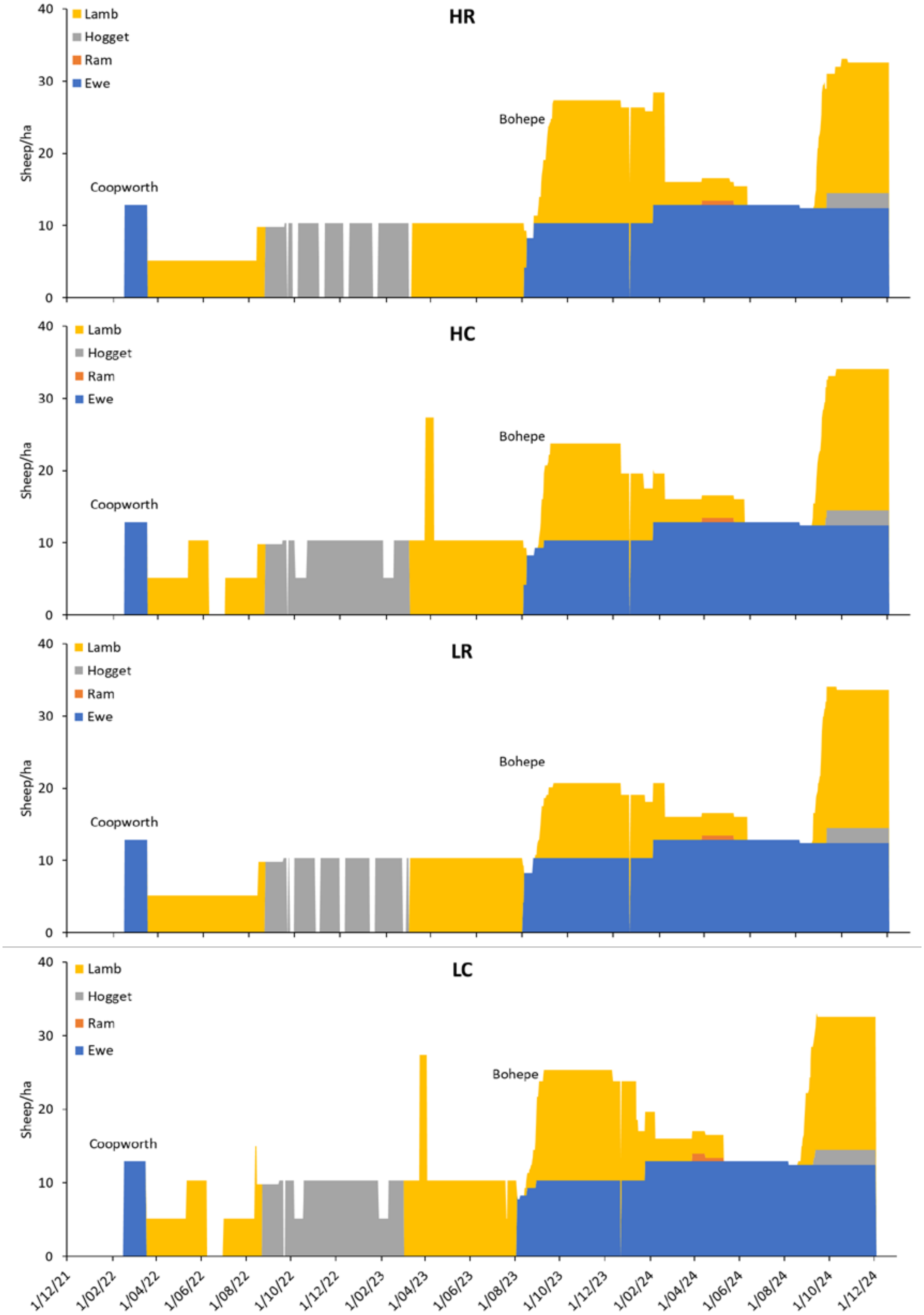

Figure 10 Stocking rate of regenerative (R) and conventional (C) x high (H) and low (L) soil fertility farms.

Animal production

All sheep are weighed at about monthly intervals to calculate liveweight gain per head per day and liveweight production from each farm.

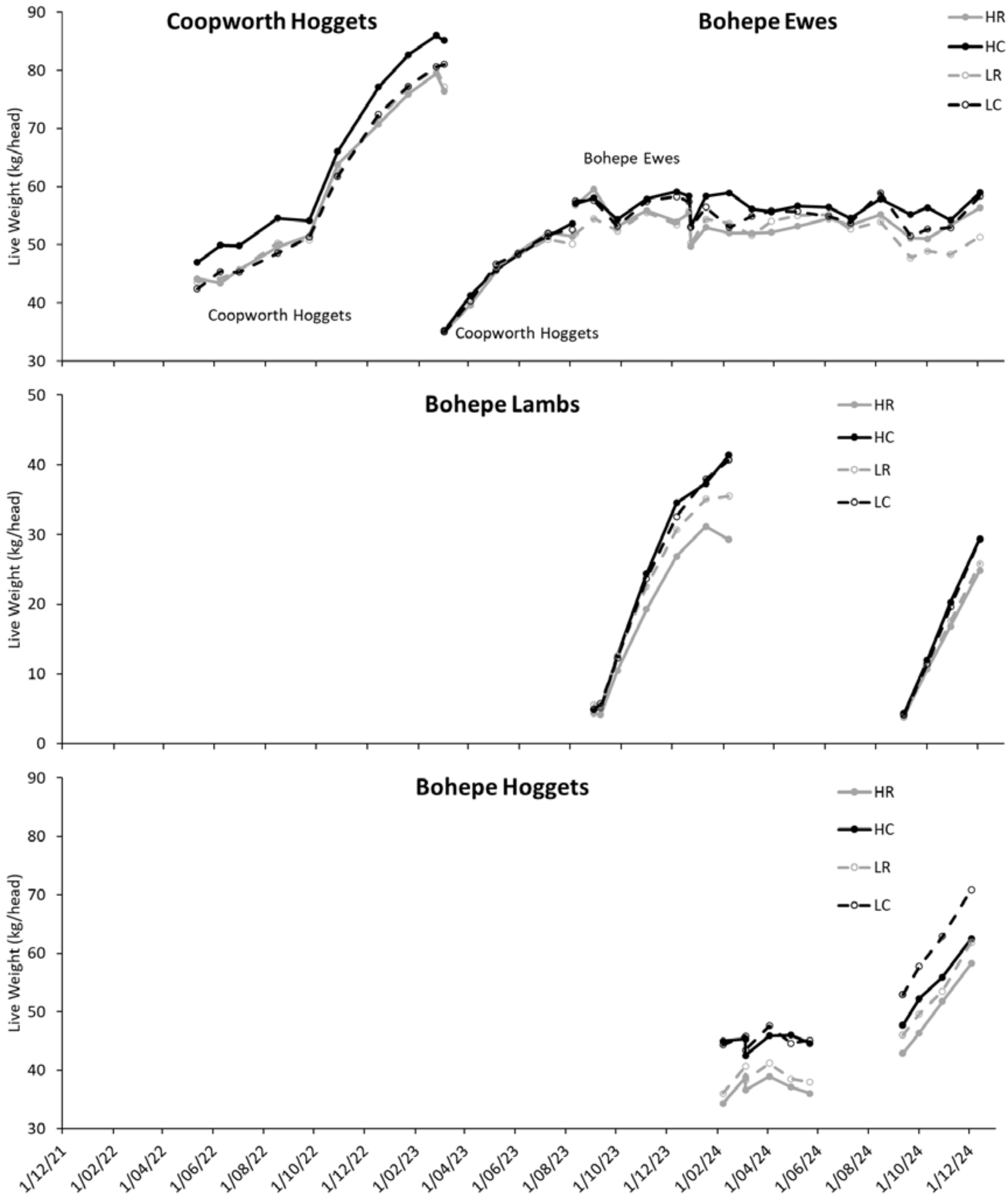

Figure 11 Sheep live weight of regenerative (R) and conventional (C) x high (H) and low (L) soil fertility farms.

NOTES